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Observation of exotic resonances for$K_s^0\pi$,$K_s^0p$and $K_s^0\Lambda$ spectra in p+A collisions at 10 GeV/c

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Abstract The review on the 2m propane bubble chamber experiment data analysis aimed to searches for an exotic baryon states for K_s^0-meson subsystems. The observation of Σ^0, $\Sigma^{*+}(1385)$ and $K^{*\pm}(892)$ well known resonances from PDG are a good tests of this method. There are found a resonant structures for $K_s^0\pi^{\pm}$, K_s^0p and $K_s^0\Lambda$ invariant mass spectra which were interpreted as $\kappa(720)$-meson, $\Theta^+(1540)$-baryon and $N^0(1750)$ or Ξ^0-baryon states, respectively.

Keywords scalar meson, · strangeness, · confinement, · bubble chamber, · multiquark · chiral symmetry

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1 Introduction

First experimental evidence for Θ^+-baryon with positive strangeness had came from experimental groups LEPS, Japan. Rotational spectra of $\Theta^+ \to K_s^0p$ has observed on this experiment [1], where significant peak in K_s^0p mass spectrum is equal to M_Θ = 1540± 8 MeV/c^2, Γ=(9.2±1.8) MeV/c^2. These values of M_Θ and Γ are agreed with such ones from PDG-2004.

Recent reports for Θ^+ observation are published where statistical significance increased for $\Theta^+ \to K_s^0p$ until 7.3 S.D. from DIANA and 8.0 S.D. from SVD2 collaborations. An opposite viewpoint is that all positive results might arise as statistical fluctuations and do not reveal a true physical effect [5].

The scalar mesons are especially important to understand because they have the same quantum numbers as the vacuum. A lighter and very broad κ pole is nonetheless possible and should be looked for in future data analyzes. The $K_s^0\pi^{\pm}$ invari-

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ant mass spectra has shown resonant structures with $M_{K^0_s\pi}$=720 MeV/c^2 and $\Gamma_e \geq$ 145(or50)MeV/c^2[3]-[4].

2 $K^0_s\pi^+$ - spectrum

A study vector mesons $K^{*\pm}(892)$ in pp interactions at 12 and 24 GeV/c by using data(280000 - events) from proton exposure of CERN 2m hydrogen bubble chamber. Total inclusive cross sections in pp interactions are equal to 0.27± 0.03 and $0.04\pm^{0.02}_{0.03}$ for K^{*+} and K^{*-}, respectively.

Figure 1a has shown the effective mass distribution for all experimental 9539($K^0_s\pi^+$)combinations with bin sizes 16 MeV/c^2[3]-[4]. The average mass resolution for $K^0_s\pi$ system is equal to ≈2%. The above dashed curve in Figure 1a is the sum of a background taken in the form of a polynomial up to the 8-th degree and 1BF function($\chi^2/n.d.f. = 73/69$). There is significant enhancement in mass range of 885 MeV/c^2, 9 S.D.,$\Gamma \approx 48$. The peak in invariant mass spectrum at M(885) is identified as well known $K^{*+}(892)$ resonance from PDG. The cross section of K*(892) production (430 exp. events) is equal to 0.5 mb at 10 GeV/c for p+C interaction. In case of bin size 13 MeV/c^2 there are negligible enhancements in mass regions of: 730,780, 890 and 970 MeV/c^2[3]-[4].

The effective mass of ($K^0_s\pi^+$)distributions for 4469 combinations over the momentum range of $P_{\pi^+} < 1.0$ GeV/c with bin sizes 31 MeV/c^2 are shown in Figure 1b. The ($K^0_s\pi^+$)spectrum in Figure 1b is taken by the sum of 8-order polynomial form and 1 BW function what is satisfactorily described ($\chi^2/N.D.F. = 43/37$)without mass range of $K^{*+}(892)$(0.75< $M_{K^0_s\pi}$ <0.98). The background by FRITIOF or polynomial methods has approximately same form when they were done approximation by 2BW functions[3]. Then there are observed significant enhancements in mass regions of: 720(7.3 S.D.) and 890(5.5 S.D.) MeV/c^2. After cut of $P_{\pi^+} < 1.0$ GeV/c in Figure 1b is shown that signal in mass range of 720 MeV/c^2 increased.

2.1 $K^0_s\pi^-$ - spectrum

Figure 2a has shown the invariant mass distribution of 3148($K^0_s\pi^-$)combinations with bin sizes 18 MeV/c^2 [3]-[4]. Figure 2a has shown that the 8-order polynomial function is approximated ($K^0_s\pi^-$)spectrum with χ^2/n.d.f.=114/65. The sum of 1BW and background taken in the form of a polynomial up to the 8-th degree($\chi^2 = 42/36$ without mass ranges of $K^{*-}(892)$[3]. The background by FRITIOF or polynomial methods has approximately same form when they were approximated with adding 2BW functions. In the ($K^0_s\pi^-$)and ($K^0_s\pi^+$) spectrum there are same significant enhancements in mass regions of 720,780,890, 980 and 1070 MeV/c^2(3.1 S.D.,≈ 45 events)(Figure 2a). The signal in mass range of 890 MeV/c^2 is identified as well known resonances $K^{*-}(892)$from PDG. The cross section of $K^{*-}(892)$ is approximately 10 time lesser than for $K^{*+}(892)$ in this experiment too. The preliminary total cross section for M(720) in p+propane interactions is larger than 30μb.

2.2 ΛK^0_s - spectrum

Figure 2b shows the invariant mass of 1012(ΛK^0_s) combinations with bin sizes 18 MeV/c^2[2]. The solid curve is the sum of the background (detained by the first method)

and 2 Breit-Wigner curves(Figure 2b). The structure of mass spectrum has shown, that the significant enhancements has been observed in two effective mass ranges 1750 MeV/c^2(5.6 S.D.) and 1795(3.3 S.D.) MeV/c^2.

These peaks could be interpreted as a possible candidates of two pentaquark states: the N^0 with quark content udsds decaying into ΛK_s^0 and the Ξ^0 quark content udssd decaying into $\Lambda\overline{K_s^0}$. The preliminary total cross section for $N^0(1750)$ production in p+propane interactions is estimated to be $\approx 30\mu$b.

3 K_s^0p - spectra

The $(K_s^0, pos.track)$ effective mass distribution for all 10534 combinations with bin size 22 and 10 MeV/c^2 are shown in Figure 3a,b, respectively. There is significant enhancement in mass region 1540(>5 S.D.,Γ_e=45 MeV/c^2) with width $\leq$ 30 MeV/c^2. At bin size 10 MeV/c^2 the (K_s^0p) effective mass spectrum has shown significant resonant structures with M = 1520 ($\geq$4.5 S.D.,$\leq$ 13 MeV/c^2),1552($\geq$ 5.9 S.D., $\leq$ 15 MeV/c^2), 1618(3.8 S.D., $\approx$ 36 MeV/c^2), and 1695 (3.8 S.D., $\approx$40 MeV/c^2). The peak in mass range of 1540 with width 30 MeV/c^2 with bin size 22 MeV/c^2 can interpret as a sum of two peaks in mass ranges of 1520 and 1552 MeV/c^2 with widths $<$ 15 MeV/c^2. These observed peaks in mass ranges of 1520 and 1695 can be a reflection from $\Lambda^*(1520)$ and $\Lambda^*(1690)$ resonances.

The K_s^0p effective mass distribution for 2300 combinations with identified protons at momentum range of $0.350 \leq P_p \leq 0.900$ GeV/c is published in [1],[4]. The K_s^0p invariant mass spectrum shows resonant structures with $M_{K_s^0p}$=1540(5.5 S.D.), 1613(4.8 S.D.), 1821(5.0)MeV/c^2. The experimental spectrum for Θ^+ agree with the calculated rotational spectra from the theoretical reports of D. Akers, V.H.Mac-Gregor, A.Nambu, P.Palazzi.

4 Conclusion

The observation of Σ^0,$\Sigma^{*+}(1385)$ and $K^{*+}(890)$resonances are a good tests for applied method. These interesting results for observation of $\kappa(720)$, $\Theta^+(1540)$ and $N^0(1750) or \Xi^0$ resonances will need to study in future experiments.

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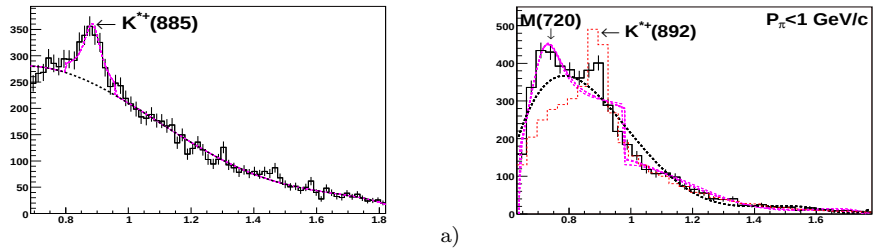
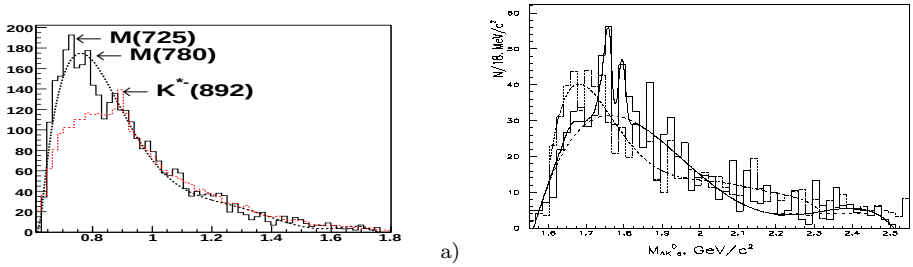


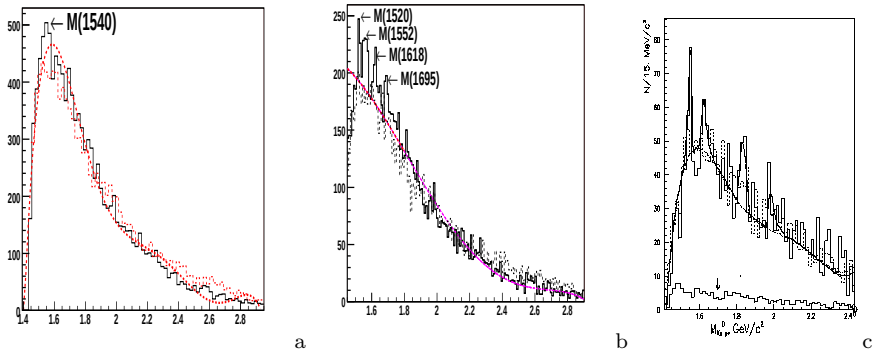
a) b)

Fig. 1 a)All comb. for the $K^0_s\pi^+$ spectrum with bin size 16 MeV/c^2; b)The $K^0_s\pi^+$ spectrum over momentum range of $P_\pi < 1GeV/c$ with bin size 13 MeV/c^2. The dashed histogram is simulated events by FRITIOF. The dashed curve is a background by polynomial method.



a) b)

Fig. 2 a)The $K^0_s\pi^-$ spectrum with bin size 34 MeV/c^2; b) The $K^0_s\Lambda$ spectrum with bin size 18 MeV/c^2.



a b c

Fig. 3 All comb. for the K^0_sp spectrum with bin sizes a)22 and b) 10 MeV/c^2;c)The K^0_sp spectrum for identified protons in range of 0.35< P_p <0.90 GeV/c($\overline{K^0}p$ comb. by FRITIOF).